PRCB CR S070164

Baseline
NSTS 60584 - Orbiter Fleet Safing Document (OFSD)
and
NSTS 60585 – End State Subsystem Requirements Document (ESSRD)

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Agenda

- Objective
- Background
- Sequence of Major Tasks
- Orbiter Fleet Safing Document Overview
- End State Subsystem Requirements Document Overview
- Summary of CR Evaluation Inputs
- Summary/Conclusion
- Back Up

Objective

- Obtain PRCB approval of:
  - NSTS 60583 - Orbiter Fleet Safing Document (OFSD)
  - NSTS 60584 - End State Subsystem Requirements Document

Background

- Requirements for safing for permanent storage or public display do not exist.
- The current safing requirements are focused on decontaminating sufficiently to allow work on the subsystem, but do not permanently decontaminate the systems.
- A joint Orbiter/Ground Ops team of subsystem, safety, environmental and Orbiter processing operation experts, that included both contractor and NASA entities, were engaged to assess vehicle safing and decontamination.

Background

- We defined and implemented an approach for establishing a set of requirements for the Orbiter end states:
  - Examined current safing procedures to determine adequacy for permanent safing. Identify gaps in procedures/decontamination processes.
  - Researched and benchmarked examples of similar safing/decontamination challenges in other programs/industry.
  - Discussed acceptability of hazards with museum entities.
  - Engaged a joint Orbiter/Ground Ops team of Subsystem, safety, environmental and Orbiter processing operation experts that included USA, Boeing and NASA entities, to develop the fleet safing plan.
    - Boeing established Technical Task Managers (TTM), former SSMs (Mar ’06) to coordinate the technical positions for the end state requirements
  - Identified all of the specific subsystem and component level hazards that need to be removed or safed and documented them in two documents:
    - Orbiter Fleet Safing Document (OFSD) and the End State Subsystem Requirements Document (ESSRD)
  - Established similar configuration management and Program review processes (LSRR/LSFR) to baseline and control these requirements.
  - Reviewed the Ferry Flight CoFR process to assure the minimum necessary rigor for safe ferry flight.

Background

- Examined current safing procedures and standards to determine adequacy for permanent safing. Identify gaps in procedures/decontamination processes.
  - Specific safety requirements for long term storage do not exist beyond the basic NIOSH and OSHA thresholds.
  - Insufficient understanding of long-term hazard potential for hypergolic systems
- Benchmarking:
  - Reviewed OV-101 hydrazine system safing prior to delivery to NASM
    - All hydrazine contaminated components removed
  - Visited the Aerospace Maintenance & Regeneration Center (AMARC) at the Davis Monathan Air Force Base.
    - Their experience with Titan safing was not applicable to an Orbiter
  - Assessed Wiltec decontamination capability at KSC
    - Their cleaning process can not eliminate out-gassing from seals
    - No well defined process for on vehicle cleaning.
  - Assessed White Sands Test Facility safing of Fleet Leader test articles
    - FRCS and Aft test articles purged and systems locked up for a year
    - Sniff checks after a year revealed contamination in unacceptable TLV ranges

Background

- Met with two different museum representatives to discussed acceptability of hazards for hardware on public display
  - National Air and Space Museum (NASM)
  - National Museum of Air Force at Wright Patterson
  - Other than dealing with hydraulic fluid, these entities have no hazardous material handling capability.
- Orbiter Fleet Safing Plan development by the joint Orbiter/GO team:
  - Current Orbiter safing and decontamination processes and procedures have were reviewed and compared to OSHA long term exposure requirements
    - Public Exposure Limits for Hypergolics is essentially “Zero” Allowable
  - Existing KSC processes meet OSHA decontamination requirements during OPF Processing, but are only intended for operational safety <u>not</u> long term storage or display
- Based on our benchmarking, assessment of the current capability to fully decontaminate all hypergolic systems, and from our review with the museum folks, we concluded that the hypergolic systems must be fully removed prior to Orbiter asset storage or display. Other fluid systems could be purged and adequately cleaned.

Sequence of Major Tasks

- Normal post-mission safing and deconfiguration (30 day DMP)
  - PRSD Cryo offload, OMS/RCS assessment and securing, some pyro securing.
- Safing to eliminate or mitigate hazards
  - Fluid Offloads, systems drained, purged and removed where required.
  - Additional pyro removals: Ku, MPMs, Crew Module Overhead Window, Side hatch, ODS docking base removal
- Configure for display
  - Negotiated with display sites: some hardware removals/re-installations
  - Vehicle closeouts for ferry and display
- Ferry ops/transport to display sites
  - Ferry kit installation
  - Weight and C.G.
  - Mate to SCA

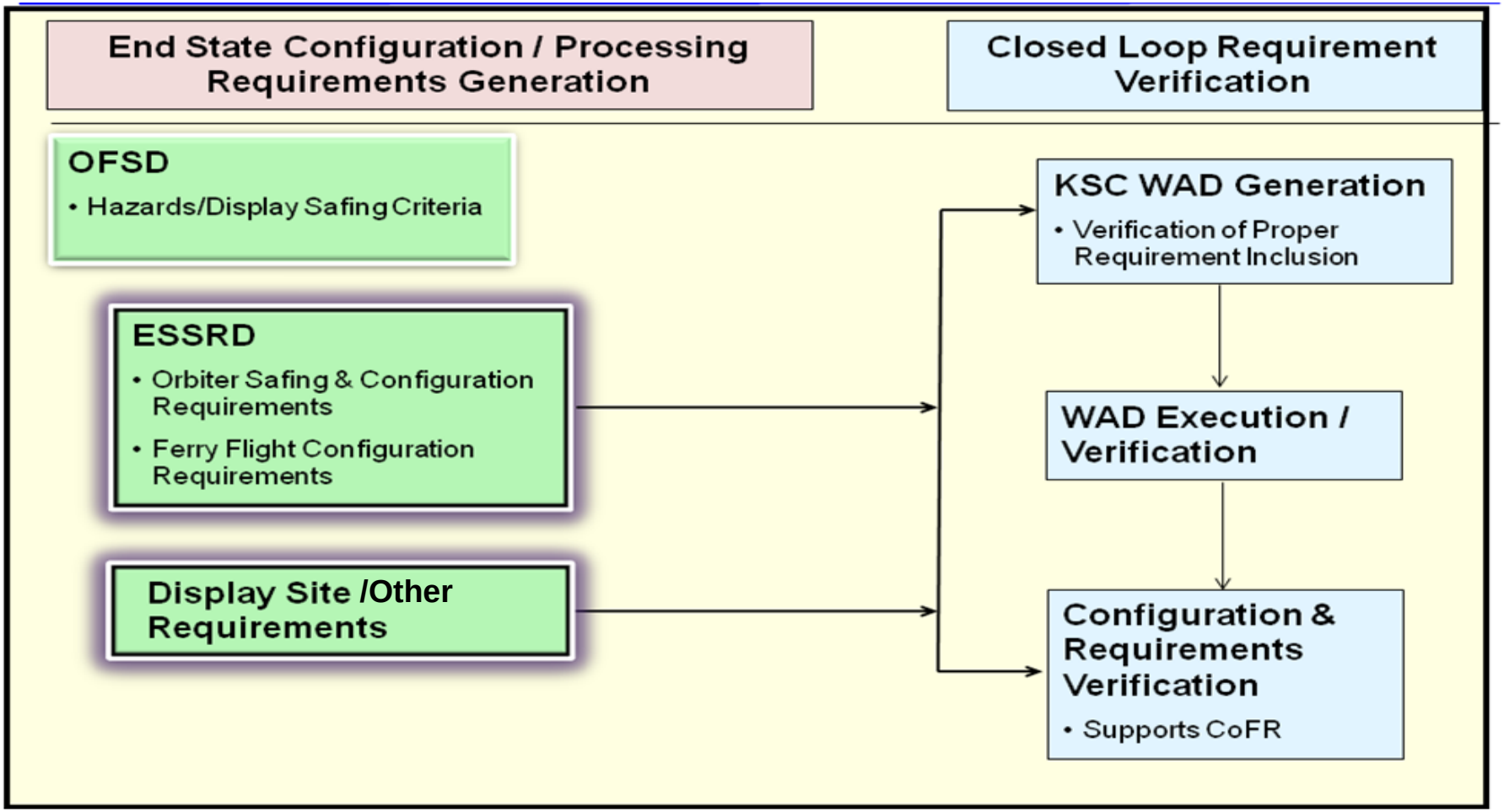
Orbiter Fleet Safing Document (OFSD)

- Purpose:
  - Establishes requirements and actions to safe and decontaminate the vehicles for long term storage, or public display.
  - Provides a composite list of active hazards (e.g. Hypergolics, Pyros, etc.) that will be mitigated or completely removed, and passive hazards and their respective cautionary notes that are not planned for removals (e.g. Fuel Cells/KOH, ET Doors/Beryllium, TPS/ Silicates).
  - Provides a pictorial reference of where the removed hazards were located on the vehicles, and where passive hazards still remain.
  - Mitigation criteria assessed by the Orbiter technical community, KSC Systems Engineering, with KSC NASA and USA Safety approval..
- Document Control:
  - Releasing as a Program approved NSTS document establishing top-level safing standards for safe public display

End State Subsystem Requirements Document (ESSRD)

- Purpose:
  - Document that establishes the requirements for safing and configuring the Orbiter subsystems and Orbiter/SCA for Ferry to display sites
  - Integrates the OFSD safety requirements and OMRSD-derived technical requirements unique to end state.
    - ESSRD requirements were specified by Design Contractor Technical Transition Managers in coordination with Subsystems Managers, Ground Ops Engineering and PRT technical review.
    - Perform Gap analysis of existing OMRSDs to determine requirements that need to be developed for safing/decontamination
    - An initial OMRSD scrub identified some 225 of 4,300 manned space flight required OMRSD requirements as having some applicability to end state safing and Ferry configuration
    - It was impractical to generate several hundred RCNs to adapt the applicable OMRSDs, though the ESSRD references OMRSD sequences/exclusions to accomplish the target subsystem safing and Ferry configuration requirements.
  - Requirements grouped according to Orbiter subsystem
- Control:
  - ESSRD will be authorized for implementation at the End State Requirements

End State Requirements Processing Overview



CR Evaluations

- CB: concur
- DA: Concur with Comments
- MO: Concur with Comments
- MS: Concur
- MV: Concur
- MX: Concur with Required Changes
- JSC EA: Concur with Comments
- JSC SA3: Concur
- JSC XA: Concur
- MSFC MP11: Concur with Comments
- MSFC MP71: Not applicable to this office
- KSC PH: Concur with Comments
- KSC MK-SIO: Concur with Comments
- KSC MK: Concur
- USA: Concur with Comments

Conclusion/Recommendation

- End State requirements are well-defined and ready to be baselined by the Shuttle Program

- Great deal of work to define implementation plans, develop configuration management processes, etc. is occurring in parallel, but requirements are mature enough to baseline which will allow NASA PH/USA Ground Operations to develop work instructions and release such for approval

- Recommend approval of PRCB CR S070164

Back Up

Precautionary Commodity Disposition

Commodity	System	Planned Mitigation
Monomethyl Hydrazine (CH_3NHNH_2)	OMS/RCS	• System drained • Contaminated components removed • System vented to atmosphere • Commodity non-detectable
Nitrogen Tetroxide (N_2O_4)	OMS/RCS	• System drained • Contaminated components removed • System vented to atmosphere • Commodity non-detectable
Hydrazine (N_2H_4)	APU	• Hyper system drained and removed • Commodity non-detectable
High Pressure Gas (He & GN_2)	MPS, ECLSS, APU, PRSD, OMS/RCS	• Vented
CDC - confined detonating cord	PYRO	• Removed and/or detonated in place
XTA - expanding tube assembly	PYRO	• Removed
LSC - linear shaped charge		
NSI - NASA Standard Initiator		
MDF - mild detonating fuse		
SMDC - shielded MDC detonating cord		
Liquid Hydrogen (LH_2)	MPS	• H_2 concentration less than 22% • System vented
	PRSD	• H_2 concentration less than .5% • System drained and vented
Liquid Oxygen (LO_2)	MPS	• O_2 concentration less than 22% • System vented
	PRSD	• O_2 concentration less than 22% • System drained and vented
Ammonia (NH_3)	ECLSS	• Less than 1 ppm • System drained, purged and vented
Freon 21 (CHCl2F)	ECLSS	• Less than 5 ppm • System drained and vented
Halon	ECLSS	• Fire suppression bottles (Halon) removed
Hydraulic Accumulators	HYD	• Accumulators removed or drained/vented
WSB PGME/Water	HYD	• System drained and vented • WSB tank residual (2.8lbs) • Document only
Waste Water	ECLSS	• System drained, iodine enriched flush, dried to less than 15 mm Hg for 1 hrs min • WCS, urine filter removed

Commodity	System	Planned Mitigation
Potable Water	ECLSS	• Drained & dried to less than 15 mm Hg for 1 hrs min • Microbial check valve removed
Avionics Cooling Water	ECLSS	• Drained & dried to less than 15 mm Hg for 1 hrs min
LCG Water	ECLSS	• Drained & dried to less than 15 mm Hg for 1 hrs min
APU Water & Gaseous Nitrogen (Injector Cooling System)	APU	• Water drained • GN2 vented
Fluorinert (FC-40)	PRSD	• Drained & dried to less than 3 mm Hg for 6 hrs min
Stored Mechanical Energy - T-0 & ET I/F QDs - Landing gear door opening assist bungee - Strut & Tire Press	 MPS MEQ MEQ	 • Document only • Energy removed • Vented struts & hard filled tires
APU lube oil	APU	• Drained and vented
LiOH	FCE	• Canisters removed
Batteries NiCd Lithium	DPS INSTR	• GPC backup battery units removed (BBU) • GPS receiver battery units removed • WLE instrumentation batteries removed • Comsec/batteries removed
Hydraulic Fluid	HYD	• Significant system residual (~60 gal.) • Document only
Beryllium (Be)	STR	• ET doors remain installed • Star trackers remain installed • Document only
Mercury	D&C	• Mercury hermetically sealed in LCDs & CRTs • Document only
Radioactive Material Americium-241	ECL	• Tests to characterize sources and levels of radiation • Document only
TPS Silica, Manmade Vitreous Fibers (MMVF)	TPS	• Document only
Boron	STR	• Approx 240 struts installed during initial build. • document only
Asbestos	PRSD	• Fuel cells remain installed (414 cu in. / 5184 grams). • Document only
Potassium Hydroxide (KOH)	F/C	• Fuel cells remain installed (catalytic residuals) • Document only
Koropon	STR	• Document only
Lead	Elect	• Document only

Orbiter Fleet Safing Document

Residual Hazardous Precautions

Commodity	Hazard • Exposure Type	End State Configuration	Display Precautions Summary
Hydraulic Fluid	Combustible Toxic • Eye Contact • Ingestion	Contained (~60 gallons) in Closed System.	• Slippage/contact precautions, if disassembled
WSB PGME/Water	Toxic • Ingestion	2.8 lbs. in enclosed WSB tank.	• Avoid inhalation/ingestion, if disassembled
Beryllium (Be)	Toxic • Inhalation	Present in solid structural components only.	• Avoid cutting, sanding, splintering or scratching/inhalation of dust
Mercury	Toxic • Skin Contact • Eye Contact • Ingestion	Mercury hermetically sealed in LCDs & CRTs.	• Avoid contact/ingestion, if disassembled
Radioactive Material (Americium-241)	Mild Radiation • Smoke detector element contact	9 detectors @ 20 micro-curries each.	• Avoid lengthy contact if disassembled
TPS Silica, Manmade Vitreous Fibers (MMVF), Carbon Carbon RCC	Respiratory irritant • Inhalation	All possible exposures require manipulation of the material.	• Avoid cutting, sanding or scratching/inhalation of fibers
Boron	Toxic • Inhalation • Splintering	Present in solid structural components only. Exposure requires manipulation of the material.	• Avoid cutting, sanding or scratching/inhalation of dust
Asbestos	Severe respiratory irritant • Inhalation	Residuals present in sealed fuel cell only. Exposure requires manipulation of the material.	• Avoid inhalation of fibers, if disassembled
Potassium Hydroxide (KOH)	Caustic • Skin/Eye Contact	Residuals present in sealed fuel cell only. Forms non-hazardous Potassium Carbonate when exposed to air.	• Avoid contact • Placard signs to be placed at F/C location cautioning not to contact power head section
Koropon Paint	Toxic • Inhalation	Paint on orbiter aluminum skin - remains in place. Cured Koropon is not an exposure issue unless sanded to dust.	• Avoid sanding or scratching/inhalation of dust
Lead	Toxic • Ingestion	Present in solder only. Exposure requires disassembly of electronic equipment.	• Avoid ingestion, if disassembled
Quick Disconnects (QD) / stored energy	Physical • Stored Energy • Pinch Points	Some stored energy remains in Quick Disconnects (QD), if manipulated. Plexiglass covers will be made available for high energy MPS (PD1, PD2 & PD3) QD's.	• Avoid contact/manipulation

ESSRD Summary

- Based on safing criteria defined in the Orbiter Fleet Safing Document (OFSD), thirty-six (36) safing requirements have been documented in the ESSRD for verification prior to ferry to Display Sites
  - APU
    - Three Fleet End State (FES) Safing Requirements
      1) Fuel System Component Removals
      2) Lube Oil System (Drain/Vent)
      3) Cooling System (Drain/Vent)
  - Fuel Cell/PRSD
    - Four FES Safing Requirements
      1) De-service PRSD Cryo System (< .5% H2; < 22% O2)
      2) De-service Water System (Drain, Vented and Dried)
      3) De-service FC-40 Coolant (Drain, Vented and Dried)
      4) Purge FCPs (vent to ambient)

- End State Safing Requirements (Cont.)
  - Hydraulics
    - Four FES Safing Requirements
      1) Hydraulic System Component Removals
      2) Water Spray Boiler Safing (GN2 Tanks Vented, Core Drained, PGME / Water tanks Drained)
      3) WSB Accumulators (Bleed GN2 to Ambient)
      4) Hydraulic Fluid (Drain)
  - MPS
    - Three FES Safing Requirements
      1) Safe Pneumatic System (Vent to Ambient)
      2) Safe LH2 System (LH2 Concentration < .5%)
      3) Safe LO2 System (LO2 Concentration < 22%)

ESSRD Summary

- End State Safing Requirements (Cont.)
  - OMS/RCS
    - Three FES Safing Requirements
      1) OMS / RCS Component Removals
         a) Following component removals, structural assessment by design contractor to verify ferry flight worthiness
      2) Propellant System Safing (Drain/Purge System to NDL)
      3) Helium System Safing (Vent to Ambient)
  - ECLSS/ATCS
    - Twelve FES Safing Requirements
      1) Life Support Component Removals
      2) Waste Water System (Citric acid flushed, purged and dried to 15mm hg for 1 hr min; Remove waste water dump filter)
      3) Potable Water System (Drained, Vented and Dried)
      4) GN2 Tanks Safing (Vent to Ambient)
      5) LCG Loop Safing (Drained, Vented and Dried)
      6) Airlock Interface Lines (Drained, Vented and Dried)

ESSRD Summary

- End State Safing Requirements (Cont.)
  - ECLSS/ATCS (Cont.)
    - Twelve FES Safing Requirements (Cont.)
      7) ATCS Component Removals
      8) ATCS ARS H2O System (Drained, Vented and Dried)
      9) ATCS Freon System (De-serviced and Dried to 5 PPM)
      10) ATCS Ammonia Boiler System (Drained, Vent < 1 PPM Max)
      11) ATCS Air Recirculation Screens, Cabin Fans only (Cleaned)
      12) ATCS IMU Fans, Inlet Wire Screen (Cleaned)
  - Avionics
    - Two FES Safing Requirements
      1) Avionics Component Removals
      2) Flight Deck Instrumentation Radiation Scan (Perform / Record)

ESSRD Summary

- End State Safing Requirements (Cont.)
  - Pyro
    - Four FES Safing Requirements
      1) Pressure Cartridges and NSI Removals
      2) Crew Module Vent Severance System (Remove Pyrotechnic Lines and T-handle)
      3) Overhead Window #8 (Expend Pyrotechnic Lines)
      4) Side Hatch (Remove Pyrotechnic Lines and T-handle)
  - FCE
    - One FES Safing Requirements
      1) SORG Microbial Check Valve Removal

ESSRD Summary

- Ferry Flight Requirements
  - During the Fleet End State flow, while safing requirements are being conducted and additional fifteen (15) Ferry Flight Requirements have been documented in the ESSRD for verification prior to ferry to Display Sites

    - Fifteen FES Ferry Requirements
      1) SCA Configure (M072-560001)
      2) Orbiter / SCA Mate (M072-560001)
      3) OMS Flight or ALTA Pods & FRCS Install (V070-000001, M072-430001, M072-316020)
      4) Tailcone/ET Ferry Doors/DMHS Install (M072-350002, M072-355002, M072-351900)
      5) PVD Doors / Plugs Install Ferry Configuration
      6) Post-Ferry Drain (Contingency – Verify No Water, Post Ferry)
      7) Hydraulic Actuator Locks Ferry Configuration
      8) Mechanical – Door/Hatch/Latch Ferry Configuration
      9) Hydraulic System #1 Landing Gear Capability

- Ferry Flight Requirements (Cont.)

  - Fifteen FES Ferry Requirements (Cont.)

    10) Landing Tires & Struts (Hard Tires / Vented Struts)
    11) Landing Gear Extension Boosters (Relieve Booster Stored Energy)
    12) Ballast as Required (Based On Post Safing Configuration)
    13) Outer Mold Line (OML) Integrity (Verify OML integrity for ferry flight)
    14) Cabin/Airlock Negative Pressure Relief Valve (Functional Checkout Prior to Ferry)
    15) Positive Pressure Relief Valves (Inspect / Clean)

ESSRD Excerpt

5.1.2 FCP/PRSD

5.1.2.1 FCP/PRSD Subsystem Safing

The End State of the PRSD Subsystem will commence after normal post landing cryogenic hydrogen and oxygen reactants deservicing per V45DP0.010. PRSD system and hydrogen and oxygen tanks will be isolated and vented to ambient. No component removals are planned.

The End State of the FCP Subsystem will commence after normal shutdown of the three fuel cells per V45CI0.010 and inert purged per V45CI0.040. The Fuel Cells H2O systems will be drained. The Fuel Cells coolant system will be drained. Jumper tubes will be installed. No component removals are planned.

5.1.2.1.1 PRSD Cryo Tanks Deservicing

Vent PRSD System and Cryo Tanks by opening T-0 isolation valve and T-0 AHC PODs and vent systems to ambient pressure. Sample H2 and O2 tank residuals after inert purging and verify H2 concentrations are below 1 % and O2 concentrations are below 22 %. Perform after Fuel Cell Securing has been completed.

FCP-SS-01	PRSD Cryo System	2.1.2.1.1	De-serviced to < 1% H2, < 22% O2

Table 2.1.3.1: Hydraulics Component Removals

Part Number	Part Name	Qty	Reference Designator	Comments
MC281-0029	Main Pump	3	50V58PP4, 50V58PP5, 50V58PP6	Removal due to APU demate. Must remove for safety and lack of permanent mounting hardware (without APU)
MC284-0597	Bellows Accumulator	3	50V58AU10, 50V58AU11, 50V58AU12	High pressure GN2 not serviceable

5.1.3 Hydraulics

5.1.3.1 Hydraulics Subsystem Safing

The hydraulic subsystems shall be safed by draining all fluids and venting pressurant gasses per the Orbiter Fleet Safing Document. Some of the following requirements will have been performed as part of normal post-flight ground operations to safe an orbiter for IFA troubleshooting or to maintain it as an LON vehicle.

The following steps are required to safe the HYDRAULIC subsystem. The order of the steps is subject to change.

1. Verify electrical power and switches to all V58 components are off.
2. Vent water spray boiler (WSB) GN2 tanks.
3. Evacuate WSB Core.
4. Evacuate the WSB PGME/Water tank.

HYD-SS-01	Water Spray Boiler	2.1.3.1.2 2.1.3.1.3 2.1.3.1.4	Verify GN2 tanks vented, core evacuated, PGME/Water tank evacuated

5. Bleed GN2 from MC621-0035 accumulators (AU5,AU7,AU9)

HYD-SS-02	MC621-0035 Accumulators	2.1.3.1.5	Bleed accumulator GN2 to ambient

6. Drain Hydraulic Reservoirs 50V58 TK4,TK5,TK6 (V58AA0.000)

HYD-SS-03	Hydraulic Fluid	2.1.3.1.6	Drain hydraulic reservoirs

7. Remove all components listed in Table 2.1.3.1. Cap affected hydraulic lines/hoses per appropriate procedures. Secure any loose lines, flex hoses, and wire harnesses that have been disconnected to the adjacent structure.

HYD-SS-04	System Components	2.1.3.1.7	Verify removal of all HYD System Components listed in Table 2.1.3.1 for Systems 1, 2, & 3

ESSRD requirements grouped by subsystem – PRSD subsystem shown

ESSRD Excerpt

1.1 Effectivity

Those End State Requirements will be in effect from wheel stop following last flight landing, with the following exceptions:

Launch-On-Need (LON) Orbiter:
Following the last flight of this orbiter, it will be processed per existing OMRSD requirements to maintain the vehicle as an LON orbiter. When the LON requirement is no longer necessary, the orbiter will be ready to begin End State Processing.

"Second to Last Flight" Orbiter:
IFA's will be evaluated to constrain any End State Processing task which might prevent Fleet implication trouble shooting evaluation.

2 End State Safing/Display Verification Requirements

ESSRD Reqmt No	System Area	Paragraph Reference	Requirement Summary
APU-SS-01	Fuel System Components	2.1.1.1.12.1	Verify removal of all Fuel System Components listed in Table 2.1.1.1 for Systems 1, 2, & 3
APU-SS-02	Lube Oil Systems	2.1.1.1.4	Drained and Vented
APU-SS-03	Cooling System (Water)	2.1.1.1.7	Drained and Vented
FCP-SS-01	PRSD Cryo System	2.1.2.1.1	De-serviced to < 1% H2, < 22% O2
FCP-SS-02	Water System	2.1.2.1.2	Drained, vented, dried to < 15mm hg for 1 hr min
FCP-SS-03	Coolant (FC-40)	2.1.2.1.3	Drained, vented, dried to 3 mm hg for 6 hr
FCP-SS-04	Fuel Cell	2.1.2.1.4 2.1.2.1.5	Purge FCPs and leave at ambient; Install jumper tubes
HYD-SS-01	Water Spray Boiler	2.1.3.1.2 2.1.3.1.3 2.1.3.1.4	Verify GN2 tanks vented, core evacuated, PGME/Water tank evacuated
HYD-SS-02	MC621-0035 Accumulators	2.1.3.1.5	Bleed accumulator GN2 to ambient
HYD-SS-03	Hydraulic Fluid	2.1.3.1.6	Drain hydraulic reservoirs
HYD-SS-04	System Components	2.1.3.1.7	Verify removal of all HYD System Components listed in Table 2.1.3.1 for Systems 1, 2, & 3
MPS-SS-01	Pneumatic Sys	2.1.4.1.1	Vent MPS pneumatic system to ambient
MPS-SS-02	LH2	2.1.4.1.2	Verify LH2 concentration <1%
MPS-SS-03	LO2	2.1.4.1.3	Verify LO2 concentration <22%
OMS/RCS-SS-01	He tank	2.1.5.1.6.a	Vent He tank pressure to ambient
OMS/RCS-SS-02	Propellant System	2.1.5.1.14	Decontaminate propellant system to NDL

- ESSRD Requirements Summarized
  - Safing and Display
  - Ferry Flight

Ferry Flight Requirements

Req. #	System	ESSRD Reference	Requirement Summary
FF-SS-01	SCA Configure	3.1	
FF-SS-02	OMS Flight or ALT Pods & FRCS	2.1.5.2	
FF-SS-03	Tailcone/ET Ferry Doors/DMHS	3.2	
FF-SS-04	PVD Doors / Plugs	2.4.1.2.1 2.4.1.2.2	Misc PVD ferry configuration
FF-SS-05	Post-Ferry Drain (Contingency)	2.4.1.2.3	Verify no water accumulation post ferry flight
FF-SS-06	Hyd Actuator Locks	2.1.3.2.1 2.1.3.2.2 2.1.3.2.3 2.1.3.2.4 2.1.3.2.5	Misc ferry configuration
FF-SS-07	Mechanical – Door/Hatch/Latch Table	3.3	Verify door/hatch/latch configuration
FF-SS-08	Hyd Sys 1/Ldg Capability	2.5.3.2	Landing gear functional test
FF-SS-09	Orb SCA/Mate	3.4	
FF-SS-10	Landing Tires & Struts	2.5.3.3.5	Hard tires/vented struts
FF-SS-11	Landing Gear Extension Boosters	2.5.3.1	Relieve the booster stored energy

OFSD Eval Comments (cont.)

	Organization	Comment	FES Team Response
1	DA/MOD	Section 2, Precautionary Commodity Disposition, Table 1, Page 2, under Commodity "Hydrazine". Comment: APU system described as "Hyper system"; system is a monopropellant (no oxidizer) and the reaction is a catalytic decomposition. Recommendation: Change description from "Hyper system drained…" to "System drained…"	Concur - updates will be made
2	DA/MOD	Section 2, Precautionary Commodity Disposition, Table 1; Section 4.3, High Pressure Gas Systems, Page 11. Comment: High pressure WSB GN2 is not included under any Commodity (e.g., "High Pressure Gas (He and GN2)", "WSB PGME/Water"). Recommendation: Add reference (i.e., "HYD") under "System" for "High Pressure Gas (He and GN2)" to account for WSB GN2 tank.	Concur - updates will be made
3	DA/MOD	Section 2, Precautionary Commodity Disposition, Table 1, Page 3, under Commodity "Hydraulic Fluid"; Section 3, Residual Hazardous Precautions, Table 2, under Commodity "Hydraulic Fluid", Page 3; and Section 4.10, Hydraulic fluid, Page 26. Comment: System residual is listed as "~90 gal" in Tables 1 and 2, but as "50 - 60 gallons" in section 4.10. Recommendation: Correct the erroneous value(s) {TBD which one is incorrect}.	Concur - updates will be made
4	DA/MOD	Section 3, Residual Hazardous Precautions, Table 2, under Commodity "WSB PGME/Water", Page 5. Comment: Fluid is not listed as being combustible. Recommendation: The 50/50 PGME/Water fluid is combustible; add "Combustible" under Hazard.	Concur - updates will be made
5	DA/MOD	Section 4.3, High Pressure Gas Systems, Page 11 Comment: High pressure WSB GN2 is not included. Recommendation: Add WSB GN2 tanks to diagram.	Concur - updates will be made
6	DA/MOD	Section 4.9, Halon, Page 25. Comment: 3 portable hand held fire extinguishers are missing in Section 4.9 pictorial. Recommendation: Show portable fire extinguishers on the diagram.	Non-concur - Portable fire extinguishers will be removed as part of nominal destow.
7	DA/MOD	Section 4.10, Hydraulic fluid, Page 26. Recommendation: Delete the word "considered", as follows: "Hazardous ~~considered~~ fluid / condition may exist…"	Concur - updates will be made
8	DA/MOD	Section 4.11, PGME, Page 27. Comment: Section title and description (i.e., "PGME") are inconsistent with previous references (i.e., "PGME/Water") to this system. Recommendation: a) Change title to "PGME/Water"; b) Change description to "Water Spray Boiler (WSB) PGME/Water coolant tank."	Concur - updates will be made
9	DA/MOD	Section 4.19, APU Lube Oil, Page 38. Comment: Diagram does not show lube oil contained within the WSB heat exchanger core tubes. Recommendation: Extend colored lines on diagram to indicate the lube oil within the heat exchanger core.	Concur - will add note to the existing diagram to indicate lube oil within heat exchanger core
10	DA/MOD	Section 4.20, LiOH Canisters, Page 39. Comment: The diagram appears to show a second set of humidity separators that should not be there. Recommendation: Use a different diagram to show the location of the stowed LiOH cans. One that includes the LiOH cans installed as well as stowed would be best.	Concur - will add note to existing diagram to indicate LiOH canisters to be removed as part of nominal destow
11	DA/MOD	Section 4.24, Radioactive Material, Page 44. Comment: Locations of 9 smoke detectors containing radioactive material Americium-241 are not shown. Recommendation: Show the smoke detector locations in Section 4.24.	Concur - updates will be made
12	MX	Asbestos matrix internal to fuel cells - potential exposure hazard	OFSD Table 1 includes asbestos
13	MX	Potential for fuel cell potassium hydroxide residuals/leeching to exterior surfaces and possibility of low voltage presence	OFSD Table 1 includes KOH
14	MX	Mercury traces in fluorescent bulbs throughout the cabin and payload bay - potential heavy metal exposure hazard	Concur - updates will be made to include

OFSD Eval Comments (cont.)

15	MX	Long-term leaching of MMH and N2O4 into propellant systems from tube and tank walls may become an exposure hazard even after thorough flushing - potential chemical exposure hazard	All exposed seals and tanks will be removed; any remaining tubes will be flushed/educted
16	JSC EA	Page 3 - LiOH is listed as FCE; should be ECLSS	Concur - updates will be made
17	JSC EA	Page 25 - only avionics bay halon bottles are included; there are also portable fire extinguishers	Portable extinguishers will be removed as part of nominal destow operations
18	JSC EA	Section 4.21 - need to include WLEIDS battery removal from OMS/RCS stinger location used for MEI data collection	Concur - updates will be made
19	JSC EA, MX	Updates to Tritium (H-3) commodity line items. Updates all pertain to documenting the use of the radioactive element Tritium in the MSBLS Decoders. 1. Add a block to sections 2 and 3 of the OFSD to reflect COMMODITY: Tritium (H-3) [See 'Comment Excerpts-OFSD' tab for item 15]	Team accepts comment. Action: Bill Roberts to update doc
20	JSC EA	There are some inaccuracies on page 3, 5 and 43 of the Orbiter Fleet Safing Document, NSTS 60584. The statement on all of the identified pages "Mercury hermetically sealed in LCDs and CRTs" is incorrect. It should state: "Mercury is sealed in fluorescent serpentine lamps within the Display Unit". In addition, if the document calls out the mercury contained in the fluorescent lamp inside the display units, then it should also call out that the Interior Lights of the Orbiter do contain a very small amount of mercury, just as any fluorescent lamp does. The mercury is contained inside the glass tube of the lamp and the lamp is covered in a Teflon sleeve with the whole lamp enclosed (practically sealed) in the floodlight chassis. In addition to the Interior Lights, the Payload Bay Floodlights also contain a small amount of mercury in their bulbs. The bulb is enclosed in a sealed floodlight chassis.	Concur - will add serpentine lamps and floodlights in the Mercury portion of the table.
21	JSC EA	Add para 4.24 Radioactive Material Potential RAM exist in components such as switches, circuit breakers, meters, and inside the three MSBLS decoders to due to unique circumstances. • Gauges or Meters with radio luminescent indicator marks, dial pointers, or alphanumerics, where the Radium paint utilized is enclosed within a sealed glass housing. • Components with radio luminescent parts or markings, such as switches and circuit breakers, where the Radium paint utilized is exposed to touch or flaking/peeling from handling activities. • Special optical glass utilizing Thorium Dioxide to provide a glass with a high refractive index and low dispersion, such as for Head-Up Displays. • Radio luminescent Signs, Markers, and Placards. • Tritium within the MSBLS decoders.	Concur - updates will be made
22	MSFC MP11	Table 1, lists Freon 21, the decon activities shown were drain and vent. Generally for chemicals like Freon regulation require to drain and vent the system using a vacuum system being careful not to release the chemical into the environment. May need to make sure on how we approach this.	Team accepts comment. However, no clarification is required. This is part of normal ops.
23	MSFC MP11	Table 1, lists Koropon, suggest to identify the primary hazardous chemical(s) in the Koropon, most likely will be hex chrome and/or lead.	Concur - updates will be made
24	MSFC MP11	Table 3 or at beginning of section 4.0, suggest listing the specific pyros in a table that can serve as a check list for addressing them since there are so many.	Team non-concurs with comment. Covered in ESSRD details

OFSD Eval Comments (cont.)

25	USA	The headers for section 2, 3 and 4 have no paragraph explaining intent of these sections. For example, section 2 is titled "Precautionary Commodity Disposition". What is it's intent? The same for sections 3 and 4.	Concur. Make the following changes: Section 2 "Precautionary Commodity Disposition". "This section identifies the specific hazardous commodities found on the Orbiters, the system in which the commodity is used on the Orbiters, the mitigation actions that will be implemented to render that system safe for public display. In essence it is a list of safety requirements." For section 3, "Residual Hazardous Precautions": " The intent of this section is to identify hazardous commodities that will still be present the Orbiters, the type of exposure hazard that will need to be managed by the display site, the actual configuration of that hazard remaining in the Orbiter, and the precaution that should be considered by the display site." For section 4: "This section provides pictorial representations of where the hazardous commodities were previously present in the Orbiters, or where there still is residual. The drawings are marked where the hazards have been removed, and where there is still some residual hazard."
26	USA	Section 4 should delineate which hazards have been removed from the Orbiters and which remain. The section is generally confusing on the actual configuration that the vehicles will be in upon delivery to the display sites.	Concur - updates will be made
27	USA	Section 4 should either remove references to "acceptable for display" indicated on several pages (page 26 hydraulic fluid, page 41 & 42 beryllium, page 45 TPS, page 49 & 50 Boron Struts). We should not presume what is acceptable for display.	Concur - updates will be made
28	USA	Section 4.4, page 14. What is meant by the word "Archive"? Add explanation in the document.	Concur - updates will be made
29	USA	Section 4.10. What is meant by "…this condition is acceptable with in-place containment processes"? Shouldn't this document outline the containment processes that will be needed at the display site for this hazardous commodity? Based on our 7/13 discussions, maybe just add "at the display site" to clarify what is meant.	Concur - updates will be made
30	USA	Section 4.11, p. 27. Spell out "PGME". Section 4.15, p. 31. Spell out "LCG".	Concur - updates will be made
31	USA	Section 4.23, p. 43. Spell out LCD and CRT. Add a verb to the text to make it into a sentence, such as "Mercury is hermetically sealed…".	Concur - updates will be made

OFSD Eval Comments (cont.)

32	USA	Section 4.24, p. 44. Add acronym “RAM” to title in parenthesis.	Concur - updates will be made
33	USA	Section 4.24, p. 44, phrase above picture. The phrase “Planned tests to characterize sources and levels of radiation of acceptable levels” is vague. Recommend using a verb to make this a sentence, and provide better explanation. Is this a requirement or a plan? What is the intent of the sentence?	Concur - updates will be made
34	USA	Section 4.26, p. 49, second sentence. The phrase “Boron Aluminum (B/AI) cracked/crushed no fibers or residue release” is ambiguous. Restate into a sentence and add further explanation to the reader regarding the intent of the statement.	Concur - updates will be made
35	USA	Section 4.28, p. 52, second sentence. Rephrase first part of sentence to read “Lead in solder joints is isolated…”	Concur - updates will be made
36	USA	Consideration should be given to the following recommended revision to table 1 and 2 of the OFSD. Table 1 of the OFSD identifies Koropon as a precautionary commodity requiring a "document only" disposition. Table 2 indicates that the Koropon Paint on the aluminum skin is toxic. The constituents that make koropon primer toxic, are specifically hexavalent chrome and lead. Suggest revising Tables 1 and 2 to identify Hexavalent Chrome as the commodity or residual hazard, respectively. Table 1 should expand the affected system designation for Hexavalent Chrome and Lead to "ALL" and Table 2 should annotate that Hexavalent Chrome is present on corrosion protected components, including anodized, chem-filmed, and koroponed-primed surfaces. Table 2 of OFSD indicates that Lead is present in solder only when in fact lead is present in koropon as well. In 1989 the Koropon formulation was changed to eliminate lead but the requalification and transition to the new formulation did not take place until 1992. In 2004, analysis of Koropon coated structures on OV-105 revealed the presence of lead in the majority of the tested locations. Subsequent analysis of airborne koropon dust during wet sanding yielded results below the limit of detection proving that wet sanding was sufficient mitigation. Add an appropriate Orbiter Hazard Commodity Location/Description in section 4.	Concur - updates will be made

ESSRD Eval Comments

	Organization	Comment	FES Team Response
1	DA/MOD	Section 4.1.3.1, Hydraulics Subsystem Safing, Page 17, in sub-section 6. Recommendations: 1. The statement, “Prior to removal of hydraulic system components, photograph the as-installed condition. Record the photograph number.” should come before the direction to remove the hydraulic system components. 2. Delete the word “determined” as follows: “Lines and other flex hoses will remain installed unless it is determined to be prudent to remove them…”	Concur - changes will be made
2	DA/MOD	Table 4.2.1.1, Life Support system Component Removals, Page 29. Recommendation: In Table 4.2.1.1 there is reference to removing 3 O2 Sensors, however Table 7.1 (Page 80) only shows CG location of 2 sensors. 3rd O2 sensor should also be listed in Table 7.1.	Concur - changes will be made
3	DA/MOD	Sections 4.2.1.1.2 (Page 27) and 4.2.1.1.4 (Page 28): Comment: In both sections there are caution notes regarding exceeding allowable gas-to-liquid pressure: “Caution: Do not exceed tank gas-to-liquid delta pressure allowable.” Should those limits be explicitly listed here or should the applicable document reference for the limits be listed?	Concur - reference to OMRSD will be added
4	MO	On Page 7, recommend change to : "listing of all End State configuration changes for safing and ferry requirements that need to be verified prior to ferry flight and/or delivery to display site.	Concur - changes will be made
5	JSC EA	EC: Although the description of processing plan is technically correct for preparing the vehicles for display, the actual details of the work done could be in conflict with existing documents, such as JSC Chit J6626: Waste Water Sample and Urine Solids Filter Request. Additionally, valuable samples from the Water Coolant Loops (or any other fluid loops) should be taken, such as effluent and filters, for post-program analysis.	These reqmts should be captured as part of Down Mission Processing reqmts or "Other" requirements
6	JSC EA	Table 3: End State Safing/Display Verification Requirement, pressure unit "mmHg" should have letter H in uppercase. Also, ECL-SS-07 Requirement Summary should read "De-service, dry to 15 mmHg for 1 hr".	Concur - changes will be made
7	JSC EA	Table 3: End State Safing/Display Verification Requirement, pressure unit "mmHg" should have letter H in uppercase. Also, ECL-SS-07 Requirement Summary should read "De-service, dry to 15 mmHg for 1 hr".	Concur - changes will be made
8	JSC EA	EV: Removing the Battery Housing of the BBU and installing just the faceplate will leave 8 holes in the BBU faceplate. Reassembling the BBU faceplate to the BBU housing without the cell stacks will return the Orbiter to its original appearance.	Return to original appearance is not required for safing.
9	MSFC MP11	Page 16, paragraph 4.1.2.1.4, placards are mentioned for the fuel cells. Please indicate if we are going to use placards on any other areas to bring attention to potential hazards that will be left on the Orbiters.	Forward Action - Need to further evaluate placards (i.e., size, OSHA standards, etc).
10	MSFC MP11	I assume that hazards associated with the remaining carbon carbon, TPS, beryllium, and/or other remaining hazards parts/materials will be communicated to the receiving museum.	Concur. This type of information will be included in the Data Pack.
11	MSFC MP11	I assume that the S&MA guys are reviewing for physical (non-health) hazards and controls (pyros, structural, etc.)	Concur. Orgs are reviewing
12	MSFC MP11	Page 9, OMS/RCS-SS-02, consider changing the summary to, "Decontaminate propellant system to NDL based on current sensing technology."	Concur - changes will be made
13	MSFC MP11	Page 21, para 2: Is it possible that the receiving museum could find propellant vapors behind the thruster throat plugs, or will decontamination or removal be completed prior to turnover? (para 15, page 22?)	Not possible. Soft goods will be removed, and the rest of the system will be educted and flushed prior to delivery
14	MSFC MP11	For the Koropon, we need also to capture "health" controls, generally per the MSDS for handling it getting to, and after the end state configuration.	Concur. This type of information will be included in the Data Pack.
15	MSFC MP11	Recommend an "introduction assumption" to both NSTS 60584 and NSTS 60585 stating that any related work to these two documents will be performed post SSME removal. If SSMEs will be installed in the Orbiter at a later date, the end state engine configuration and any safety issues will be addressed at that time.	Non-Concur - Requirements currently assume SSME's installed for display/ferry flight reqmts; as "SSME" reqmts are defined, display/ferry reqmts will be updated

ESSRD Eval Comments (cont.)

16	KSC PH	1) Table 3, Page 8: Removal and return to the OEM for cleaning of the WCS is considered a down-mission processing activity. T&R groundrules dictate that the WCS would be 'excessed' from the vendor location. The WCS would only be returned to KSC for installation under a "display" requirement.	Concur - WCS reinstall will be captured as a Display reqmt
17	KSC PH	2) Section 4.1.1.1, page 11: At wheel-stop of the last flight, failure analysis capability will no longer be available at the NSLD or the vendors.	Concur - clarification will be made to wording
18	KSC PH	3) Sections 4.3.1.1.1, 4.3.1.2.1, 4.3.1.3.1, 4.3.2.1, and Table 4.3.8, Pages 32, 33, 36: These hardware items "Shall be removed and returned to the depot" should read "shall be removed and returned to the appropriate depot". These depots should not be confused with the NASA Shuttle Logistics Depot (NSLD) in Cape Canaveral, FL.	Concur - clarification will be made to wording
19	KSC PH	4) Section 4.5.8.2.1, Item #9 page 47: Logistics will not store this hardware. It should be "excessed" immediately if it is not required for reinstallation.	Concur - clarification will be made to wording
20	KSC PH	Page 57, sections 5. 5.1, 5.2, 5.3, and 5.4 The entire page 57 does not reflect a current ferry configuration requirement when SSME's (including EMHS and DMHS) are not installed in the orbiter vehicle. When Engines are not installed the heat shield closeout covers are required to be installed on the Orbiter Vehicle Base Heat Shield closing up engine holes. Therefore, we suggest the following fixes: Paragraph 5.0 Integrated Ferry config: Add EMHS or remove the words "Dome-Mounted" from the paragraph. "Heat Shields" can be defined as the Orbiter-Vehicle Base Heat Shield, the eyelids or Engine Mounted Heat Shields, plus the Dome Mounted Heat Shields. You can add to this para that if SSME's are not installed, then the Heat Shield closeout Covers are required on their position., Paragraph 5.1 SCA Config: Make sure that the referenced tech order has steps to install the Heat Shield Closeout Covers as required., Paragraph 5.2 Tail Cone/ET Ferry Door / Dome-Mounted Heat Shields Installation: Should include the Engine Mounted Heat Shields (EMHS) installation. More importantly, the installation of Heat Shield Closeout Covers when engines are not installed is required for Ferry Flight config so the actual sequential installation order should be 1) EMHS instl, 2) DMHS instl, 3) Tail cone instl, 4) ET ferry doors instl, OR 1) Heat Shield closeout covers instl 2) Tail cone instl, 3) ET Ferry Doors instl., Paragraph 5.4 SSME instl:Current SSME Project Office End-State requirements call for ALL engines to be removed from the Orbiters (RSS-9037 SSME Transition Mgmt Plan, and the MSFC SSME T&R Exit Plan for KSC, Rev 2). Therefore, the sentence that calls for installing Heat Shield Closeout Covers if SSME is not required on any position (Engine 1, 2, 3) is necessary. Furthermore, section 5.4 (SSME instl) should really be performed before sections 5.2 and 5.3. To follow sequential order, we suggest to move section 5.4 prior to section 5.2	Non-Concur - ESSRD currently assumes SSME's will be installed for display and ferry flight; once "SSME" configuration is determined, ESSRD will be updated.
21	KSC PH	Although the 28 vdc power system will be safed, additional safeguards should be implemented to prevent the inadvertent activation of RF radiation sources, should 28 vdc ever be re-applied to the vehicle. Of primary concern are the TACANs, which radiate pulsed RF at power levels of ~ 1kW. Also of some concern is the KU Band System, which could radiate if the gimbals were unlocked. Recommend "Cap and stow" power connectors to these LRUs as a secondary safeguard to the public against any possible unexpected RF radiation exposure.	Orbiter will no longer be able to be powered upon final power down at KSC; extra precautionary steps not required
22	USA	On page 11, under 4.1.1.1, APU Subsystem Safing, delete the first sentence referencing the verification of IFA resolution. No other systems indicate this. There are current requirements to resolve IFAs, with the exception of the very last flight, for which this will not apply. Also, the ESSRD presumes that the orbiter has been released from mission status, and IFA resolution is part of the process to release it.	Concur
23	USA	At the end of the Shuttle Program Safing and decontamination may require additional procurement of some (TBD) ground system and ferry flight materials. Program spares and non-flight consumables will be utilized to their fullest extent without impacting preflight operations and fly out.	Agree with Comment - Ongoing action to identify hardware required to support safing
24	USA	In ESSRD, section 1, last sentence page 7 states ESSRD contains all End State configuration changes/safing/display/ferry requirements. It does not actually contain all display req. Volume XX will also provide requirements for Orbiter display. Recommend deleting the word "display" from the sentence on page 7.	Concur - changes will be made